ENVIRONMENTAL PROTECTION

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UPGRADE OF CIRCULATING WATER SUPPLY IN GLASS PRODUCTION

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The experience in the development and service of circulating water supply systems at glass factories is described, The reconstruction of such system has made it possible to decrease to one-tenth the consumption of freshwater.

A marked industrial uptick started in the middle of the 1990s after a substantial decline caused by the transition to new economic conditions. This is also true of glass factories and primarily factories producing glass containers.

The VODGEO Research Institute together with the Vladimirgrazhdanproekt Institute has carried our a project directed at upgrading circulating water supply systems at several factories of the Gus'-Khrustal'nyi District in the Vladimir Region. The purpose of this project was to provide rational circulating water systems at glass factories and cost-efficient cooling of machinery.

The analysis of glass factories identified the general features and, accordingly, general disadvantages of existing water supply schemes, which led to new approaches for upgrading these systems and improving them.

Water systems constructed 30 – 50 years ago have long ceased to satisfy the current ecological and cost-effect requirements, whereas water-cooling systems (cooling towers and spray-cooling ponds) are unsatisfactory and do not ensure a required cooling water temperature. This is compensated by excessive feed of freshwater from surface or subsurface sources into the circulating water system, which inevitably leads to an excessive discharge of blowdown water containing impurities to surface water reservoirs. Water purification systems are absent or imperfect, which also contributes to polluting water reservoirs.

The main consumers of circulating water at glass factories are granulators, compressor stations, vacuum pumps, batch loaders, level gages, TV cameras, and others, depending on the specifics and the completeness of the production cycles (high-pressure fans, melting furnaces, etc.). Each type of equipment requires a particular quality and temperature of circulating water; therefore, the practice of uniting the industrial water supply in a single system has not been justified.

The most frequent kinds of pollutants of circulating water at glass factories are petroleum products and suspended compounds. As a rule, pollutants arrive at the water system from granulators where water from glass-forming machine chutes and lubricant-coolants from cutters penetrate the granulator simultaneously with melted glass. According to published data [1], the requirements on the quality of water consumed in chilling glass-forming machines are the following:

– temperature not higher than 40°C;

– content of suspended materials not more than 30 mg/liter;

– content of ether-soluble materials up to 100 mg/liter.

Waste water generated by glass production has the following concentrations of contaminants (mg/liter): suspended materials, 100; ether-soluble, 250. Requirements on the chemical composition of liquid waste are not specified.

The majority of heat is transferred to the circulated water supply from granulators at the moment of mold replacements or other (including emergency) operations, which occurs within a relatively short time span when melted glass is discharged into the granulator. This requires a special approach to designing systems of circulating water supply, in particular, water coolers.

Variations in Circulating Water Temperature in the System under Mold Replacement

Duration, min	Water temperature, °C
0	32
15	38
30	43
40	46

[1] VODGEO Research Institute, Russia; Krasnoe Ekho Joint-Stock Company, Russia.

Duration, min	Water temperature, °C
50	49
60	54
70	56
80	58
90	60
100	61
120	60
130	58
140	55
150	52
160	48

The maximum temperature of circulating water (50 – 60°C) is observed 1 h after the beginning of the transition and lasts for around 2 h.

At the same time, the required temperature for compressor-cooling water is 27 – 32°C and for vacuum pumps cooling, not higher than 40°C. The qualitative composition of cooling water may vary within a wide range; in particular, its hardness may vary from 0.2 to 6.0 mg · equ/liter depending on the type of equipment and the manufacturer.

The performed studies and analysis of the work of systems and of requirements imposed on cooling water quality made it possible to identify the main directions for the development of new water supply systems and reconstruction of existing ones at glass factories, which primarily imply splitting the water supply system into the “dirty” and “clean” circulating cycles.

In “dirty” water-circulating cycles the requirements on the quality and temperature of circulating water are the lowest. These cycles have to serve granulators and other equipment (drives, chutes, etc.) not requiring cooling water of high quality and of a low temperature; from these cycles petroleum products, suspended material, and other contaminating agents may arrive at the circulating system.

“Clean” water-circulating cycles can serve individual machines (for instance, a batch loader) or groups of machines with identical or similar requirements on the quality and temperature of chilling water. Such water circulation systems may be united (or split) depending on the location of the equipment on the production site or on the general scheme (a need to interrupt a water stream near a machine or the presence of residual pressure).

Below we describe an example of the reconstruction of the circulating water supply system on the first territory of the Krasnoe Ekho JSC in the context of the above approach.

Before the reconstruction, the production of glass at the Krasnoe Ekho JSC (workshops 1 and 2) had a common circulating water supply system and a local one. The old scheme is shown in Fig. 1*a*. This system used to serve the following consumers:

Workshop 1:

– granulator 1 with water flow rate of 7.2 m^3/h (during mold replacement the maximum flow rate could reach 36 m^3/h);

– granulator 2 with flow rate of 14.4 m^3/h (during mold replacement — up to 36 m^3/h);

– moreover, the two granulators could not simultaneously have a maximum flow rate;

– two vacuum pumps with flow rate of 3.6 m^3/h, the maximum temperature of cooling water 40°C, the temperature difference for the vacuum pumps — 7°C (specifications);

– TV camera — 0.72 m^3/h;

– level gage — 1.65 m^3/h.

The vacuum pumps, the level gage, and the TV camera were chilled from the household and drinking water pipeline. The water from this equipment was discharged into a return pipeline of the general system and acted as replenishment. The water from drinking fountains in the amount of 0.36 m^3/h was also discharged into the return line of the system and served as additional replenishment.

Workshop 2:

– a granulator with water flow rate of 10.8 m^3/h (during mold replacement the maximum flow rate could reach 36 m^3/h);

– two vacuum pumps with cooling water flow rates of 3.6 and 7.2 m^3/h, respectively, maximum cooling water temperature — 40°C, temperature difference for vacuums pumps — 7°C;

– TV camera — 0.72 m^3/h;

– level gage — 1.65 m^3/h.

The local circulating water cycle intended for chilling the batch loader in workshop 1 had a circulating water flow rate of around 5.5 m^3/h.

The total circulating water system used to operate in the following way: heated water from the granulators and other technological equipment was discharged into the pipelines and chutes of the return line of the system and by gravity arrived at a heated water reservoir located at the pump station, from where it was pumped via a hot water pump K100-80-160 (4K-12) and fed into the spray-cooling pond acting as the water cooler.

The cooled water was returned to the same pump station to the chilled water reservoir, which was separated from the heated water reservoir by a concrete partition and via cold water pump K100-65-200 (4K-8) was fed to the production process.

The system was replenished from an artesian well into the cooled water reservoir. The pump ÉTsV-10-63-65 installed in the well had a capacity of 63 m^3/h and developed a head of 65 mm water column. The pump operated round the clock with short stops.

Based on the above data, a water balance scheme of the system was prepared (Fig. 1*a*). It was accepted for the balance that irreversible water losses in the granulators of workshop 1 are equal to 2 m^3/h and in workshop 2 — 1 m^3/h. The losses on evaporation and drop entrainment in the spray-cooling pond are equal to 4% of the flow rate, i.e., approximately 4 m^3/h.

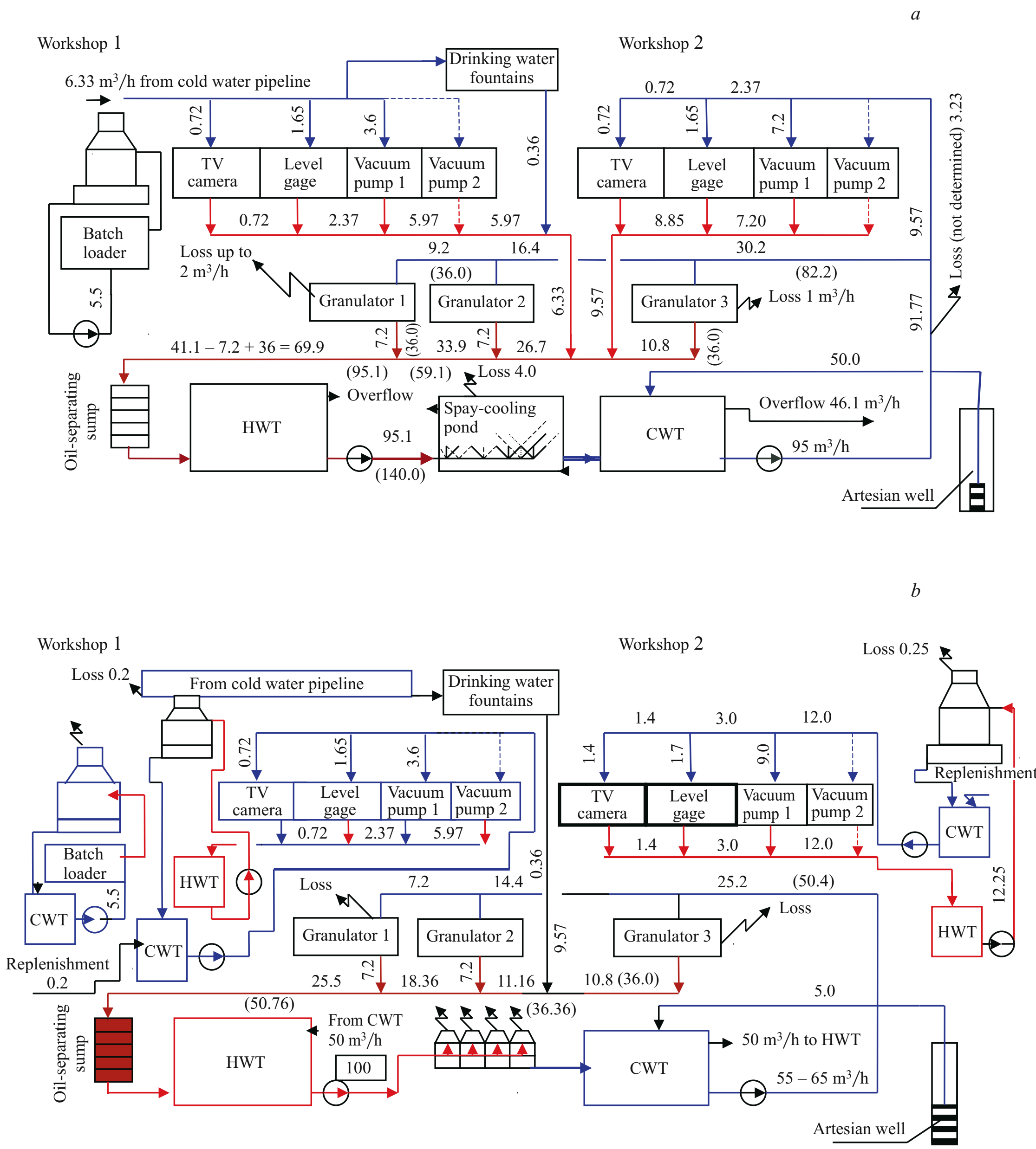

Fig. 1. Scheme of circulating water balance in the cooling system at Krasnoe Ekho JSC before (*a*) and after (*b*) reconstruction: HWT) heated water tank; CWT) cooled water tank.

The flow rate values in the system required at the moment of a mold replacement (transition) are indicated in brackets (Fig. 1*a*). The quantity of water pumped by the heated-water pump and the artesian well pump are taken as average values per hour taking into account stops and start-ups (95.1 and 50 m^3/h, respectively).

The unsatisfactory performance of the circulating water system was caused by the following main factors:

– the quality of circulating water did not meet the requirements with respect to critical and expensive equipment pieces (TV cameras, level gages, etc.), which made it necessary to use drinking water for these purposes or frequently purify the water conduit;

– uncoordinated work of pumps (for hot and cooled water) caused the hot water pumps to stop at a low level of water and cease its feed to the cooler, i.e., caused an increase in the total temperature of water in the system, which made it necessary to increase the supply of artesian water to dilute the circulating water and lower its temperature and, consequently, lead to the discharge of water via the cooled water tank overflow in quantities comparable with the artesian pump capacity;

– inefficient performance of the chiller.

We have developed and implemented measures intended to eliminate the above listed drawbacks. The analysis of data on required quantity, quality, and temperature of water for

TABLE 1

Water-circulation cycle	Circulating water flow rate, m^3/h	Irreversible loss (replenishment), m^3/h	Replenishment source
	"Clean" cycles		
Batch loader	5.5	0.10	Water pipeline
Vacuum pumps, level gage, TV camera:			
workshop 1	10.0	0.20	The same
workshop 2	12.0	0.25	″
	"Dirty" cycle[*]		
Granulators in workshops 1 and 2	55.0 – 65.0	5.00 – 7.00	Artesian well
Total	82.0 – 92.0	5.50 – 7.50	–

[*] The "dirty" cycle can be replenished from the water pipeline by means of intensified blowdown of the "clean" cycles, which makes it possible to do without artesian water. For this purpose blowdown water from the heated water tanks of the "clean" cycles is discharged into the return pipelines of the total circulating system of the factory.

each equipment unit made it possible to develop a more perfect water supply system, whose meaning is clear from the new scheme of the water balance of the cooling water systems at the company (Fig. 1*b*).

The system is divided into three "clean" and one "dirty" cycles:

– the previous batch-loader cycle remained unchanged;

– two independent cycles for workshops 1 and 2 serving TV cameras, level gages, and vacuum pumps;

– the "dirty" cycle serving all granulators which makes full use of the previous scheme and equipment of the general circulating water supply system.

The numerical data of the proposed water balance scheme are given in Table 1.

Heated and cooled water tanks were upgraded to provide hydraulic coordination of joint operation of the tanks, pumps, and water coolers, which excludes ineffective blowdown water discharge from the system. To raise efficiency and to save electricity consumption, we recommend replacing the previous circulating pumps by less powerful pumps with parameters ensuring the optimum operating conditions in the system.

The spray-cooling pond was replaced by another type of cooler: highly efficient small-size water towers designed by the VODGEO Institute (produced by the Aloris M Company) were installed, which make it possible to cool circulating water by 10 – 15°C.

To improve the quality of water in the "dirty" circulating cycle, we recommended installing petroleum- and oil-collecting drum-type devices developed by the VODGEO Institute [2] on the granulators and in the oil-separating sump.

The implementation of the proposed measures has significantly improved the performance of the water supply system of the company:

– the operation of circulating pumps is stabilized and inefficient water waste in the system is eliminated;

– consumption of freshwater has decreased to nearly one-tenth;

– the discharge of non-purified water to the water reservoir has stopped;

– by improving the circulating water quality in local circulating cycles, the reliability of cooling the technological equipment has improved.

Thus, the reconstruction of old circulating water systems at glass factories and construction of new systems should be carried out by splitting the scheme into "clean" and "dirty" water-circulating cycles and taking into account the required quality and temperature of circulating water for each equipment item or group of similar machines. The "dirty" cycle should be replenished using blowdown water from the "clean" water-circulating cycles.

The described example of reconstructing the circulating water system at the Krasnoe Ekho Works indicates that satisfying the above recommendation decreases freshwater consumption at glass factories to about one-tenth, which for a circulating water rate of 100 m^3/h saves more than 1000 m^3 of freshwater per day.

REFERENCES

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